IS 5184 (1969): Code of Safety for Hydrofluoric Acid [CHD 8: Occupational Safety, Health and Chemical Hazards]

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(Reaffirmed 2009)

Indian Standard

CODE OF SAFETY FOR HYDROFLUORIC ACID

(Second Reprint MARCH 1993)

UDC 661.491.431 : 614.8

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 7

November 1969

AMENDMENT NO. 1 DECEMBER 2006
TO
IS 5184 : 1969 CODE OF SAFETY FOR HYDROFLUORIC ACID

(*Page* 5, *clause* **4.1.1,** *last sentence*) — Substitute the following for the existing

'THRESHOLD LIMIT

The threshold limit value Ceiling value, TLV(C): 3 ppm (2 mg/m^3). The threshold limit values of hydrofluoric acid as F are as TLV-TWA' 0 5 ppm, STEL 2 ppm'

(*Page* 19, *clause* **5.2.6.2)** — Insert the following clause after **5.2.6.2**

'**5.3 Incompatibles** — Hydrofluoric acid should be stored away from oxidizing agents, reducing agents, combustible materials, organic materials, metals, acids, alkalis'

(CHD 8)

Reprography Unit, BIS, New Delhi, India

Indian Standard
CODE OF SAFETY FOR HYDROFLUORIC ACID

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(*Continued on page* 2)

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(*Continued from page* 1)

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Indian Standard

CODE OF SAFETY FOR HYDROFLUORIC ACID

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 21 May 1969, after the draft finalized by the Chemical Hazards Sectional Committee had been approved by the Chemical Division Council.

0.2 Hydrofluoric acid is highly toxic to all forms of life. Its high chemical reactivity and corrosivity present severe hazards to human life and process equipment. Due to its increasing use in the manufacture of a number of fluorine chemicals, such as, chlorofluoro hydrocarbons, fluorine containing plastics, synthetic cryolite and aluminium fluoride; a complete knowledge and understanding of the hazards associated with hydrofluoric acid is essential for its safe handling in industry.

0.2.1 This standard attempts to guide the users in the recognition of these hazards and in the recommended handling procedures. The information given should be utilized to the fullest extent and should be supplemented with additional information on design aspects of plants and equipment.

0.3 In the preparation of this standard, the chemical safety data sheet No. SD-25 for hydrofluoric acid published by Manufacturing Chemists' Association, Inc., Washington, D.C., USA, has been liberally consulted. Figures 1 and 2 of this standard are reproduced from the same publication by the courtesy of the publishers.

0.4 This standard is one of a series of Indian Standard codes of safety for hazardous chemicals.

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1. SCOPE

1.1 This code describes properties of hydrofluoric acid, the nature of hazards associated with it and the essential information on storage, handling, packing, labelling, disposal of waste, cleaning and repair of containers, selection and training of personnel, personal protective equipment and first-aid.

1.1.1 This code does not deal with specifications for design of buildings, chemical engineering plants, storage vessels, equipment for operations control and waste disposal.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 4155-1966* and IS : 4167-1966† shall apply.

3. PROPERTIES OF HYDROFLUORIC ACID

3.1 Physical Properties — Some of the important physical properties of hydrofluoric acid are given below:

		Anhydrous Hydrofluoric Acid		*Aqueous Hydrofluoric Acid*
		Liquid	Gas	
a)	Colour	Colourless, fuming (commercial acid may be slightly tinted)	Colourless, forms white mist in contact with air	Colourless (commercial acid may be slightly tinted)
b)	Odour	Pungent, irritating	Pungent, irritating	Pungent, irritating, varies with strength
c)	Relative density, 4°/4°C	10	—	Varies with strength
d)	Boiling point, °C at 760 mm Hg	19.51 ± 0.05 –		Varies with strength
e)	Melting point, °C	–83.37	—	do
f)	Flammability	Nonflammable	Nonflammable	Nonflammable

3.2 Chemical and Hazardous Properties — Some such important properties of hydrofluoric acid are given below:

a) *Corrosivity* Anhydrous hydrofluoric acid in gaseous or liquid form is corrosive to most materials. In solution or in presence of moisture, it vigorously attacks almost all materials.

b) *Reactivity* Both the anhydrous and aqueous acids will attack glass, concrete and certain metals, especially those containing silica, such as cast iron. They will also attack natural rubber, leather and many organic materials.

*Glossary of terms relating to chemical and radiation hazards and hazardous chemicals.
†Glossary of terms relating to air pollution.

3.3 Commercial Strength

a) Anhydrous Hydrofluoric Acid — 99.0 percent HF, *Min*

b) Aqueous Hydrofluoric Acid — 300 to 80.0 percent HF

4. HAZARDS ASSOCIATED WITH HYDROFLUORIC ACID

4.1 Health Hazards

4.1.0 *General* — Anhydrous or aqueous hydrofluoric acid in liquid or vapour form is dangerous when in contact with the eyes and skin, or if taken by mouth. Both the liquid and vapour in contact with any part of the body may immediately cause serious burns which may become extremely painful. Both the liquid and vapour are particularly dangerous to the eyes. Strong concentrations of the vapour may injure the respiratory or gastro-intestinal tracts if breathed or ingested. The vapour has such a sharp and penetrating odour that the inhalation of seriously toxic quantities is unlikely unless the victim is trapped in such a location that escape from the vapour is impossible.

4.1.1 *Threshold Limit* — Threshold limits are intended as guides in the control of hazards and should not be regarded as fine lines between safe and dangerous concentrations. They represent conditions within which it is felt that workers may be repeatedly exposed, day after day, without their health being adversely affected. The threshold limit value accepted at present for an 8-hour working day is three parts per million of hydrogen fluoride by volume in air (2 mg /m^3).

4.1.2 *Acute Toxicity*

4.1.2.1 *Local effects* — Contact of liquid or vapour of hydrofluoric acid with the eyes rapidly causes severe irritation of the eyes and eyelids. If the hydrofluoric acid is not rapidly removed by thorough irrigation with water, there may be prolonged or permanent visual defects or total loss of vision and destruction of the eyes. Burns of the skin may differ widely depending upon the concentration of hydrofluoric acid. When the contact is with lower concentrations (20 percent or less), the burns do not usually manifest themselves until several hours have elapsed. Contacts with higher concentrations are usually detected in a much shorter period.

4.1.2.2 *Systemic effects* — Hydrofluoric acid vapour is extremely irritating to all parts of the respiratory tract. Severe exposure will lead to rapid inflammation and congestion of the lungs. The concentration of fume which produces acute effects varies with exposure; 50 parts per million or more may be fatal when breathed for 30 to 60 minutes. If swallowed, hydrofluoric acid will immediately cause severe irritation of and damage to the esophagus and the stomach. Coincidentally, severe irritation to the respiratory tract will also occur.

4.1.3 *Chronic Toxicity*

4.1.3.1 Chronic poisoning by exposure to hydrofluoric acid, liquid or vapour, has not been recorded. However, since the effects of a single exposure may be severe, all employees handling hydrofluoric acid should have preplacement physical examinations to determine their general fitness to work in areas where the acid is handled.

4.2 Fire and Explosion Hazards

4.2.1 *Possible Hydrogen Generation* — Hydrofluoric acid in itself does not constitute a fire or explosion hazard. It is nonflammable and it will not promote ignition in contact with wood or other organic materials. There is, however, a latent fire or explosion hazard due to the possible generation of hydrogen in shipping containers, piping or in equipment used in the handling and storage of the acid. This is even possible in the case of anhydrous hydrofluoric acid where moisture may have been introduced into containers or equipment either directly as water or through the entrance of moist air, either compressed or atmospheric.

4.2.2 *Overheated Containers* — Tank cars, cylinders and drums containing hydrofluoric acid should never be heated Containers should be screened from the direct rays of the sun and stored in a location where temperatures preferably below 38°C can be maintained. When prevailing temperatures reach or exceed 52°C, provisions shall be made for cooling the containers. Containers which become overheated to the point where their capacities to hold normal pressures are exceeded are likely to rupture violently.

4.2.3 *Outage in Filled Containers* — Tank cars, cylinders and drums are never filled completely at the point of manufacture. Outage or space is always provided above the liquid level to compensate for liquid expansion as temperatures increase. No liquid hydrofluoric acid, either aqueous or anhydrous, should ever be added to a container which would reduce the required outage to a dangerous level.

4.2.4 *Dilution or Contamination in Containers* — The outlet from a tank car or cylinder of anhydrous hydrofluoric acid should never be submerged in water or any other liquid. A suckback of the liquid in the container may cause a rapid generation of heat and pressure which could result in a serious explosion. No water, dilute acid or other liquids should ever be added to a steel container used for aqueous hydrofluoric acid. A container reclosed after such contamination is likely to rupture with extreme violence.

5. HANDLING AND STORAGE

5.1 Anhydrous Hydrofluoric Add

5.1.0 *General* — Every precaution shall be taken to guard against health hazards wherever anhydrous hydrofluoric acid is handled. If leakage or

spillage occurs, only properly protected personnel should remain in the area. Leaking containers should be removed to the outdoors or to an isolated, well ventilated area, and the contents transferred to other suitable containers or disposed off in a safe manner. All spillage should be flushed promptly with water. Excessive quantities of anhydrous hydrofluoric acid should be neutralized with soda ash or lime before admitting wastes to drains and sewers.

5.1.1 *Handling of Cylinders*

5.1.1.1 The following rules are designed to prevent accidents in the handling of compressed gas cylinders. They should be rigidly observed in the case of anhydrous hydrofluoric acid cylinders. It should not be assumed, however, that every acceptable safety procedure is contained herein. When in doubt concerning the proper handling of an acid cylinder or its content, consult the acid supplier:

a) Never drop cylinders nor permit them to strike each other violently.

b) Never use a lifting magnet nor a sling (rope or chain) when handling cylinders. A crane may be used when a safe caradle or platform is provided to hold the cylinders.

c) When returning empty cylinders, the purchaser's name and address should be removed. The bill of lading should specify the number of cylinders, the name of the purchaser and the fact that the cylinders are empty. A copy of the bill of lading should be sent to the purchaser. Valves shall be closed before shipment. See that cylinder valve protective caps and outlet caps are closed securely before shipping.

d) Only cylinders complying with the existing gas cylinder rules shall be used.

e) Valve protective caps should be kept on cylinders except when cylinders are in use.

f) Cylinders shall not be filled except by, or with the consent of, the owner, and then only in accordance with the existing regulations. The filling ratio permitted at present to 0.8.

g) Never attempt to mix gases in a cylinder except for non-reactive gases such as dry air or nitrogen which are recommended for pressurizing.

h) It is illegal to remove or change the numbers or marks stamped into cylinders without written authority from the Department of Explosives.

j) Never use cylinders for rollers, supports, or for any purpose other than to carry anhydrous hydrofluoric acid.

k) Open cylinder valves slowly. Never use wrenches or tools except those provided or approved by the acid manufacturer. Wrenches

should be of the solid face type, not pipe or adjustable wrenches. Never hammer the valve wheel or stem wrench in attempting to open or close the valve.

m) Make sure that the threads on adapters are designed to engage with those on cylinder valve outlets. Never force connections that do not fit.

n) Pressure gauges or other accessories provided for use with other products shall not be used on cylinders containing anhydrous hydrofluoric acid.

p) Never attempt to repair or alter cylinders or valves.

q) Cylinders should be protected against any excessive rise in temperature. Cylinders may be stored in the open but should be protected against extremes of weather and from contact with the ground beneath to prevent rusting. During winter, cylinders stored in the open should be protected against the formation or accumulations of ice or snow. In summer, cylinders stored in the open should be screened against exposure to the continuous direct rays of the sun.

r) No part of any cylinder containing anhydrous hydrofluoric acid should ever be subjected to a temperature above 52°C. A direct flame should never be permitted to come in contact with any part of a cylinder.

s) Never store cylinders near highly flammable substances such as solvents, gasoline and waste.

t) Cylinders should not be exposed to continuous dampness.

u) Store full and empty cylinders in separate locations to avoid confusion.

v) Do not store cylinders near elevators or gangways, or in locations where heavy moving objects may strike or fall on them.

w) Be careful to protect cylinders from any object that will produce a cut or other abrasion in the surface of the metal.

5.1.2 *Emptying of Cylinders*

5.1.2.0 *General* — Steel cylinders for anhydrous hydrofluoric acid are equipped with a special valve for discharge which should not be used as a control valve. The discharge line should include a suitable adapter for connecting the line to the cylinder valve, and a needle valve for regulating the flow of acid from the cylinder. Consult the acid supplier for details. The cylinder valves are designed for use with anhydrous hydrofluoric acid and should function without difficulty. However, if a cylinder valve should stick or perform improperly, the customer shall not attempt to remove the valve. The acid supplier should be consulted for instructions. Pouring or emptying into open vessels should never be attempted. Distillation methods direct from cylinder are not recommended. Never apply direct heat or a

flame of any kind against the cylinder. Where anhydrous acid is discharged from a cylinder into other liquids, the deliver tube shall not be passed below the surface of the liquid unless a vacuum break is provided between the equipment holding the liquid and the cylinder. Because the acid is confined in the cylinder under relatively low pressures at ordinary temperatures, it would be very easy to set up a condition whereby a siphon effect would be produced, and the liquid drawn back through the discharge pipe into the cylinder. This could result in the formation of dangerous pressures in the cylinder.

5.1.2.1 *Emptying into storage tanks or closed vessels* — Although the cylinder for anhydrous hydrofluoric acid is designed and constructed primarily as a safe vessel for transporting and storing the commodity, it should be remembered that it is not to be used as an item of process equipment while in the possession of the buyer. Hence, any means of handling cylinders or removing the contents by methods other than those described below are considered unsafe:

a) Liquid or gas may be withdrawn at moderate rates from a cylinder above 19.5°C and below 52°C. This method is recommended only when the anticipated consumption of acid is small. Never apply heat directly to a cylinder to facilitate discharge.

b) For operations in which it is necessary to withdraw liquid from cylinders by the aid of externally introduced pressures to increase the rate of delivery, it is recommended that the cylinder and contents be cooled below 19.5°C before admitting dry compressed air or inert gases to the cylinder. By so doing, the operator is assured that the flow of dry air or inert gas will be into the cylinder and that the acid will not back up into the compressed air or gas line. If it is not practicable to cool the cylinder, the operator should determine accurately the vapour pressure within the cylinder, open cylinder valve, and then introduce compressed dry air or inert gas at a pressure at least 0.35 kg/cm^2 greater than the determined pressure within the cylinder, but in no case more than 2.8 kg/cm^2. The cylinder valve should be closed after pressurizing has been completed. The air or gas line should then be turned off completely before reopening the cylinder valve.

c) It is essential that the compressed air or inert gas used for pressurizing cylinders be completely dry. Any water introduced during the admission of air or gas might give rise to a dangerous reaction within the cylinder. An inert gas, such as nitrogen, is satisfactory when compatible with the usage in process.

d) The internal cylinder pressure will serve to force the acid from the cylinder into the storage tank or process equipment provided that the pressure in the equipment does not exceed the pressure within the cylinder. For connecting the cylinder to the process

unit, an outlet assembly recommended by the acid supplier shall be used.

e) For withdrawal of liquid the cylinder should be inverted and securely fastened before connecting it to the storage tank or process unit, and remain inverted until empty and the cylinder valve is closed.

f) To transfer the acid from the cylinder into the storage tank, the latter should first be cooled below the boiling point of the acid (19.5°C), otherwise a back pressure may accumulate which would halt the flow of acid from the cylinder. The valve in the storage tank vent line may be opened, if necessary, and all other valves closed (*see* Fig. 1). The cylinder outlet should then be connected to the storage tank filling connection. Then the valve in the storage tank filling connection should be opened. Last of all open the cylinder valve and transfer the acid to the storage tank. After the acid has been transferred, the valves should be closed in the following order: (a) the cylinder valve, (b) the valve in the storage tank filling connection, and (c) the valve in the storage tank vent line, if open. Then the cylinder may be disconnected.

NOTE — Storage tank and lines should be of proper construction and provision should be made for cooling them.

5.1.2.2 *Direct transfer from cylinder to vaporizing process unit* — To transfer from the cylinder into the vaporizing process unit (*see* Fig. 2) the boiler should first be cooled below the boiling point of the acid while adding the initial charge of acid, otherwise a back pressure may accumulate which would halt the flow of acid from the cylinder. The valve in the boiler vent line may be opened, if necessary, and all other valves closed. The cylinder outlet should then be connected to the line leading to the boiler. Then valve *B* should be opened. Open the cylinder valve *A* last and transfer a weighed quantity of acid calculated to half fill the boiler. Turn off boiler vent valve and valves *A* and *B*, then open valve *C* and heat contents of boiler to a temperature not in excess of 60°C. The rate of flow of gas from the boiler may be controlled by regulating the heat and by throttling valve *C*.

When a drop in the delivery rate of gas indicates that the boiler is nearly empty, close valve *C*, cool the boiler and repeat operations recommended above. Be sure that the cylinder valve is closed before disconnecting the cylinder.

NOTE — The boiler and lines should be of proper construction and should be provided with a means of thermostatically controlling the heat input.

5.1.2.3 *Operating cylinder valves* — Various types of suitable valves are used on anhydrous hydrofluoric acid cylinders and the instructions on the label or tag of each cylinder should be followed explicitly. It is important that gas leaks around the valve stem be stopped by tightening the packing

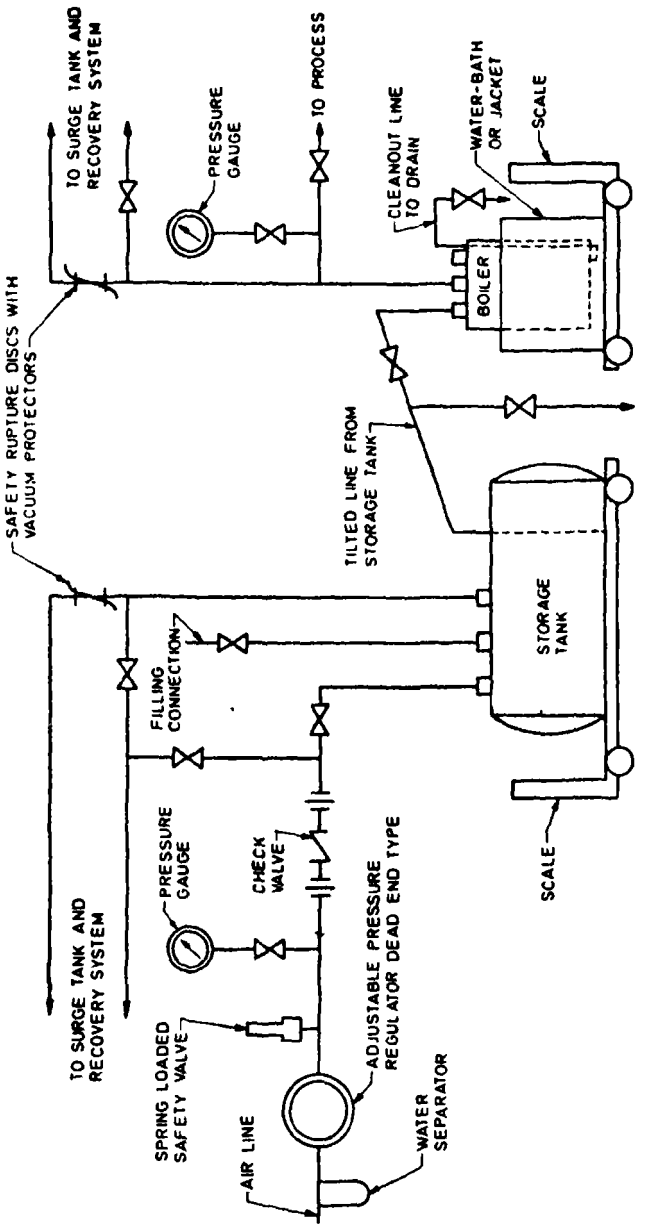
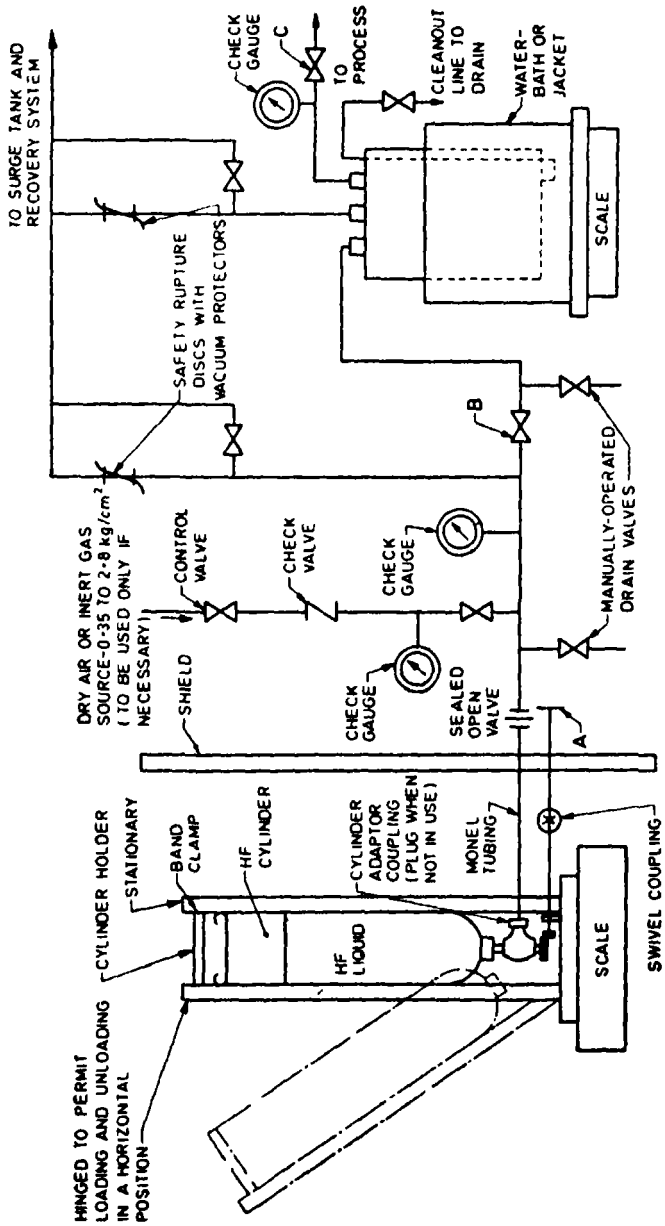


FIG. 1 RECOMMENDED EQUIPMENT FOR HANDLING AND VAPORIZING ANHYDROUS HYDROFLUORIC ACID



Main Valves:

A — Hand wheel coupled to stem (to be fully open or shut)

B — HF liquid inlet control valve

C — HF gas outlet control valve

FIG. 2 RECOMMENDED EQUIPMENT FOR VAPORIZING MODERATE QUANTITIES OF ANHYDROUS HYDROFLUORIC ACID DELIVERED AT MODERATE PRESSURES DIRECT FROM A CYLINDER

nut. Further, the consumer's unloading connection to these valves should be of such thread specifications as to conform with the valve outlet nipple threads. In all cases, the valve outlet nipple thread should be lubricated with grease containing powdered graphite before each connection with the unloading apparatus and after disconnecting, to facilitate the replacement of the outlet cap. Apply only to external threads. Never remove the valve from the cylinder. Always close the cylinder valve and replace the valve outlet cap during intermittent withdrawals or before returning the empty cylinder to the acid supplier. The steel valve protection cap on the cylinder should always be kept in place when cylinder is not in use or when returning the empty container. This large cover shields the valve from mechanical damage.

5.1.2.4 *Empty cylinders* — Cylinders shall be substantially empty, the valve outlet cap shall be replaced and closed securely, and the valve protective cap shall be replaced before the containers are offered for return shipment.

5.1.3 *Unloading of Tank Cars*

5.1.3.1 *Placement of tank car for unloading* — Unloading dock should be in the open and exposed to fresh air in order to dissipate vapours. See that train or engine crew accurately spots the car at the unloading line. Unloading track should be level. Brakes should be set and wheels blocked on all cars being unloaded. Caution signs should be so placed on the track as to give necessary warning to persons approaching car from open end or ends of siding, and should be left up until after car is unloaded and disconnected from discharge connection. (Sign should be of metal and bear the works 'STOP — Tank Car Connected' or 'STOP — Men at Work', the word 'STOP' being in letters at least 10 cm high and the other words in letters at least 5 cm high. The letters should be white on a blue background. It is recommended that derails be placed at open end or ends of siding approximately one car-length from the car being unloaded, unless car is protected by a closed and locked switch or gate.

5.1.3.2 *Safety rules to be observed by unloaders* — Unloading operations should be performed only by reliable persons properly instructed and made responsible for careful compliance with instructions. Contents of car tank should be discharged only in the daytime or when adequate lighting is provided. Tank car should not be allowed to stand with unloading connections attached after unloading is completed, and throughout the entire period of unloading or while car is connected to unloading device the car should be attended by the unloader. Water in ample quantity (safety shower preferred) should be immediately available at the unloading dock. Should any acid contact the skin, the first aid directions listed in **8** shall be followed.

Tank cars used in the anhydrous hydrofluoric acid service have special valves and safety devices to facilitate the safe removal of the contents. The

consignee shall ascertain that the car is properly positioned and that all valves, lines, equipment and connections in the receiving system are in normal safe operating condition before attempting to unload the acid.

5.1.3.3 *Dome fittings* — The dome fittings on the tank car should consist of the following:

a) *Loading plug* — Some cars are equipped with a hole in the manway cover plate closed with a steel pipe plug which shall not be tampered with under any circumstances.

b) *Safety valve* — This valve is located in the centre of the manway cover plate and is set, by the supplier, to open at the authorized emergency venting pressure of the car. This valve shall not be disturbed.

c) *Air inlet and liquid unloading valves* — These valves are completely overhauled and checked by the supplier before the tank car is filled, consequently there is little likelihood of a car arriving at destination with a leaking valve. Any leakage will be indicated by vapours around the valve. If the fuming is not serious, the consignee may check the valves to make sure they are closed tightly, and that the packing nuts are tight. In case there is serious fuming, however, do not attempt to adjust valves. Get in touch with the supplier immediately and follow his instructions. Make certain that the valves are tightly closed before removing valve outlet nipple plugs. Following unloading of the car and release of pressure, the valves should be tightly closed, the plugs lubricated and screwed tightly into place before the car is returned. Workmen should always wear protective clothing when handling these valves. Under no circumstances should consignee make any repairs or alterations to tank car valves or other appurtenances.

5.1.3.4 *Acid storage tank* — The anhydrous hydrofluoric acid storage tank shall be equipped with a filling inlet, pressure gauge and vent connection, in addition to any other needed connections. It is important that the vent connection be hooked up to purchaser's acid fume absorption system in order to avoid danger from vapours when the tank is vented, The vent lines from either the acid storage tank or tank car should in no case be permitted to enter any part of liquid. Such a practice would be most dangerous for the reason that a reduction in vapour pressure inside the storage tank or tank car could cause liquid to be sucked back into the tank with consequent danger of a disastrous explosion.

5.1.3.5 *Unloading with compressed air* — The unloading schedule listed herein is based on the use of dry compressed air for unloading the tank car. Such air shall be free from oil and foreign matter and be well dried. To insure this, an air drier should be installed in the air line and the air supply taken from the top of the reservoir, which should be drained at regular intervals. The air line leading to the tank car should be blown out thoroughly

before making connection to the car. Any water admitted to the car would react rapidly with the acid, generate heat, and create a dangerous rise in pressure.* The pressure applied to the tank car shall not exceed two-thirds of the designed relief pressure of the safety device on the car. Car should be unloaded at the lowest pressure possible. Vent storage tanks before starting the unloading operations to assure compliance. The method of unloading is in general as follows:

a) First of all, make sure that valve on standpipe is closed.

b) Make connection from cargo tank to storage tank.

c) Open air inlet valve and slowly apply unloading pressure (the air pressure shall never exceed the safe working pressure of tank).

d) Open the valve on the standpipe slowly until there is a normal flow of acid into the storage tank.

e) When the truck is empty, shut off the air and vent off the pressure.

f) After pressure has been vented, disconnect air line.

g) Do not disconnect the acid unloading line, close valves (or replace blind flanges) on the standpipe and air line.

If a spill or overflow should occur during transferring operation, the supply of air should be stopped, valves shut off, and spill cleaned up before other actions are taken.

5.2 Aqueous Hydroufloric Acid

5.2.1 *Polyethylene Carboys*

5.2.1.1 *Handling* — The carboys should be handled with reasonable care to avoid splitting the wooden or plywood outer container or injuring the neck. Before moving, carboy caps should be securely tightened and any spilled acid should be rinsed from the necks or other parts of the outer drums or boxes. No other materials should ever be added to a carboy. Certain chemicals mixed with residual quantities of acid may generate sufficient heat to destroy the polyethylene vessel. The containers should never be steamed out or otherwise exposed to sources of excessive heat.

5.2.1.2 *Storage* — A cool dry place should be provided for the storage of the carboys. The containers should be kept particularly dry at their bases to prevent deterioration of plywood and staples or the wood and nails at the bottom cleats or surface. Excessive changes from cold to hot and *vice versa* cause the polyethylene carboy to deform.

5.2.1.3 *Venting and discharging* — Loosen the carboy cap carefully by hand using acid resistant gloves and other protective equipment. Alternatively, a strap wrench may be used on the cap to open or close the carboy. After venting the carboy carefully to atmospheric pressure, the contents

*Use of a flammable gas as a substitute for dry compressed air is not recommended.

may be withdrawn. After each withdrawal, or when empty, the cap should be rctightencd. Carboys should always be emptied by gravity. Air pressure shall never be used. The use of a siphon system made of acid resistant material, with a bulb starter, is a satisfactory and safe method for discharging.

5.2.1.4 *Empty containers* — Carboys shall be completely drained and closures secured on the necks tightly before returning to the supplier.

5.2.2 *Polyethylene Drums in Outer Steel Drums*

5.2.2.1 *Handling* — Before drums are moved, the closure and vent plugs in the upper head should be tightened securely. Any acid on the metal head should be rinsed off with plenty of water. The drums should be handled with reasonable care in an upright position. Rolling the drums on their sides is not recommended. Drops or impacts which are likely to deform the steel drums should be avoided since the resulting deformation of the inner drum might reduce the basic outage and cause the contents to spurt out when the closure or vent plugs are removed. No other materials should ever be added to the polyethylene drum. Certain chemicals mixed with residual quantities of acid may generate sufficient heat to destroy the polyethylene container. The drums should never be steamed out or otherwise exposed to sources of excessive heat. The outer steel drums have small holes drilled near the bottom chime to permit rinse water or rain water to drain off. In handling the drums, care should be taken to prevent contact with the liquid draining from the steel drum since it may contain residual concentrations of acid.

5.2.2.2 *Storage* — The drums should be stored in a cool dry place on blocks or pallets to elevate them from the floor to permit drainage. The storage location should have a drain and facilities for flushing the floor with water. Excessive changes from hot to cold or *vice versa* cause the polyethylene drum to deform.

5.2.2.3 *Venting and discharging* — Loosen the vent plug on the upper head of the drum carefully using a metal wrench designed to operate the closure. Acid resistant gloves and other protective equipment should be used. After the drum has been vented carefully to atmospheric pressure, the contents may be withdrawn. Specially designed pour-out spouts or spigots made of plastics which can be tightened into the threads on the closure or vent flanges are available. The supplier of acid should be consulted for details. After each withdrawal, or when empty, the closure and vent caps should be rctightencd. Drums should always be emptied by gravity. Air pressure shall never be used. The use of a siphon system made of acid resistant material, with a bulb starter, is a satisfactory and safe method for discharging.

5.2.2.4 *Empty drums* — Drums shall be completely drained and the closure and vent plugs shall be replaced and tightened securely before returning to the supplier.

5.2.3 *Rubber Drums*

5.2.3.1 *Handling* — Drums should be handled with reasonable care and should not be dropped. Before moving, the closure device should be examined and tightened to assure security of seal. The drums should be moved and handled, prior to use, in an upright position. No other materials should ever be added to the rubber drum. Any substance other than hydrofluoric acid may cause violent chemical reaction, damaging the interior surface or lining, if any, and rendering the drum unfit for further service.

5.2.3.2 *Storage* — Drums should be stored in a cool place under cover with closures up. Avoid contact with oils or grease, which soften the rubber, or prolonged exposure to the direct rays of the sun. Full drums should not be stored longer than necessary. The drums may deteriorate under conditions of prolonged storage.

5.2.3.3 *Venting and discharging* — Loosen the drums plug, cap or flange slowly before disengaging it. Acid resistant gloves and other protective clothing and equipment should be worn and used. For drums equipped with a divided metal closure consisting of a split sleeve, a gasket and a cap, slowly loosen the two retaining nuts and do not disengage until the internal pressure has been released. The cap can then be removed safely. Drums equipped with a paraffin-impregnated rubber plug held in place with wires may be vented by loosening the wires. If drums have threaded rubber plugs, a long-handled socket wrench applied with strong, even pressure should be used. Do not hammer closures or plugs. Drums should always be emptied by gravity. Air pressure shall never be used. The use of an all-rubber siphon, with bulb starter, is a satisfactory and safe method for discharging. After withdrawals, the drum closure shall be replaced and tightened securely.

5.2.3.4 *Empty drums* — Drums shall be completely drained and closures shall be secured before returning to the supplier.

5.2.4 *Steel Drums, Lined* — Recommendations for handling, storage, discharging and the return of lined steel drums are comparable to those given for unlined steel drums in **5.2.5.**

5.2.5 *Steel Drums, Unlined*

5.2.5.1 *Handling* — Before moving drums, the closures should be inspected and tightened, when necessary, to insure against leakage. Drums of this class may be moved by rolling on their forged steel hoops provided that the closures are tight. The larger and heavier drums may be lifted by means of a hoist with a chain and drum hook attachment. The hooks should engage the drums at the chimes or rolling hoops.

5.2.5.2 *Storage* — Drums should be stored on their sides with closures up and away from heat. Exposure to sunlight for prolonged periods should be avoided. Prolonged storage of filled drums should be avoided. To prevent chronic deterioration of drums while they are beyond the control of the acid supplier, it is recommended that users of acid retain drums in

storage for a period not in excess of 90 days. When stocks of drums are held for longer periods, the supplier of acid should be consulted for advice. In any event, the venting practices prescribed in **5.2.5.3** should be observed.

5.2.5.3 *Venting during storage and before discharging* — Although unlined steel drums are passivated to assure safety in transportation, hydrogen gas may be formed by the action of the acid on the metal in normal storage. Increases in temperature may also augment pressure formation within the drum. To relieve this pressure, vent drums upon receipt and at least weekly thereafter by loosening the plug with a long-handled socket wrench. Where drums are equipped with caps instead of plugs, a specially designed wrench should be used. Acid resistant gloves and other protective equipment should be used. Because of the explosive properties of hydrogen, open flames and sparks shall be kept away from drum openings at all times. On drums equipped with standard closures, the plug threads should not be lubricated. The cap threads on drums having alternative standard closures should be lubricated before replacement.

5.2.5.4 *Discharging* — Drums should be emptied by gravity only. Air pressure shall never be used. A siphon made of neoprene, polyethylene, lead or steel is satisfactory and safe method for discharging. Carefully observe all safety precautions described in this code. Replace closure at once after the required amount of acid has been withdrawn or when the drum is empty.

5.2.5.5 *Empty drums* — The addition of water or solutions of any other substance to a drum before or after emptying is absolutely prohibited. The inside shall not be washed, since this will destroy the internal passivation and promote deterioration. Drums shall be drained completely and the plugs or caps shall be secured in place before returning to the supplier.

5.2.5.6 *Return* — Drums are thoroughly inspected when returned to suppliers of acid for refilling, nevertheless in the interest of general safety and effective performance, steel drums containing acid should be inspected at regular intervals. Any evidence of leakage, insecure closure, deformation of the heads by pressure, dents from handling, or water standing on heads, should be noted and appropriate corrective measures taken. Where there is any question regarding measures to be taken, or where safety is involved, consult the acid supplier.

5.2.5.7 *Warning* — Under no circumstances should water, aqueous solutions or any other substance ever be added to a steel drum used for packaging hydrofluoric acid. Serious internal corrosion may occur due to the disturbance of the inner passive film. Such a disturbance may cause the drum to develop leaks or, if the cap is secured, may cause the drum to rupture violently due to the generation of pressure in a confined space.

5.2.6 *Tank Cars* — Same as for anhydrous acid (*see* **5.1.3**).

5.2.6.1 *Explosion hazard* — Open flames, unprotected electric lights, sparks or smoking in the dome area may ignite hydrogen in the tank car.

No open flame of any kind should ever be permitted near any opening of the tank for any purpose whatsoever. An incandescent electric light, with gas proof socket and connection, or an explosion-proof flashlight may be used with safety. Smoking is strictly forbidden in the vicinity of the dome. All tools used in connection with unloading shall be kept free from oil, dirt and grit. Never strike tank fittings with tools or other hard objects. Do not use a hammer and chisel for loosening dome fittings, for connecting and disconnecting the tank car fittings to and from the plant air and acid lines, or for any other purpose at any time while the tank car is filled or under discharge pressure. FAILURE TO OBSERVE THESE PRECAUTIONS MAY RESULT IN THE IGNITION OF GAS FROM THE DOME AND CAUSE AN EXPLOSION. The tank car shall not be used for any product other than aqueous hydrofluoric acid unless express consent in writing is obtained from the supplier. The introduction of water or other solutions or substances may damage the tank or cause the formation of an explosive gas mixture. The purchaser should never invite this risk. Under no circumstances should air pressure in excess of 4.2 kgf/cm^2 be used for unloading the car tank. If more than 4.2 kgf/cm^2 air pressure is necessary, an acid pump should be provided for discharge. Use of air beyond the stated pressure constitutes a hazard and may result in tank damage or possible bursting. Should any hazardous condition arise, immediately close air supply and do not reopen until repairs have been completed.

5.2.6.2 *Sampling of product* — The fill-hole of a tank car may be removed and a representative sample taken by filling a small neck bottle made of polyethylene or other resistant material as it is lowered slowly from the surface of the acid to the bottom of the tank, using an iron rod with its lower end specially formed or fitted with an iron slip-hold attachment, secured to the neck of the bottle. Alternatively, the introduction of a tee and valve at any desired point in the unloading line to the storage tank will permit easy withdrawal of samples.

6. PACKING AND LABELLING

6.1 Packing — Hydrofluoric acid is packed in steel tanks. In case of dilute acids, the containers are rubber lined. High density one piece polyethylene carboys may be used for acid of 40 to 60 percent strength.

6.2 Labelling — All containers of hydrofluoric acid shall bear the label given in Fig. 7 of IS : 1260-1958*. The lower half of the label shall have the following words printed in red letters. Any other label or warning or other statement required by statues, regulations or ordinance may also be used in combination or separately.

*Code of symbols for labelling of dangerous goods. (Since revised and split into various parts).

HYDROFLUORIC ACID, ANHYDROUS/AQUEOUS

DANGER : EXTREMELY HAZARDOUS
LIQUID AND VAPOUR CAUSES SEVERE BURNS
WHICH MAY NOT BE IMMEDIATELY PAINFUL
OR VISIBLE

Do not get in eyes, on skin, on clothing

Do not breathe vapour

Store out of sun and away from direct heat

7. PREVENTIVE MEASURES

7.1 Handling — All precautions shall be taken to guard against health hazards wherever aqueous hydrofluoric acid is handled. The degree of hazard increases proportionately to the concentration of the acid. If leaks of spills occur, only properly protected personnel should remain in the area. Leaking containers should be removed to the outdoors or to an isolated well ventilated area, and the contents transferred to other suitable containers or disposed of in a safe manner. All spillage should be flushed promptly with water. Excessive quantities of acid should be neutralized with soda ash or lime before admitting wastes to drains and sewers.

7.2 Spills and Leaks

7.2.1 *Anhydrous Hydrofluoric Acid* — Since the anhydrous acid is a low boiling, fuming, corrosive liquid, leaks may result in the discharge of liquid or gas, or both. In case of a leak involving a liquid discharge such as would occur from the valves and fittings connected to the eduction or dip pipe in a storage tank, the tank should be cooled if possible and, in any event, the pressure should be vented to the absorption system before the leak is repaired. Frequently gas leaks can be repaired by the operator working from the windward side, or by inducing a draft away from the workmen by means of a blower fan. Leaks at the cylinder valve may be eliminated by tightening the stem, packing nut or outlet cap. If a cylinder leak is such that it can not be stopped by ordinary methods, the cylinder should be removed from the storage or use area and exhausted into the absorption system or it should be placed in such a position that it will gradually lose its contents without damage or hazard. Hydrofluoric acid gas dissipates rapidly. Workmen should be thoroughly familiar with hydrofluoric acid equipment in use and with safe methods for its repair. They should also be familiar with the safety equipment required.

7.2.2 *Aqueous Hydrofluoric Acid* — Leakage of aqueous hydrofluoric acid is equally as dangerous as the anhydrous acid, but not quite as difficult

to handle, Leaking containers of aqueous acid may spill large quantities of liquid which severely corrodes concrete and is readily absorbed by porous materials such as wood. Therefore, such spills should be flushed with water.

7.3 Employee Education and Training

7.3.1 A well-informed and well-trained man is an asset to himself and others in assuring safety on all jobs; an uninformed and untrained man is a hazard. The education and training of employees to work safely and to use the personal protective equipment or other safeguards provided for them is a responsibility of supervision. Safety in handling hydrofluoric acid depends upon the effectiveness of the employee's education, training and supervision. Unauthorized and untrained employees should not be permitted in areas where it is being handled.

7.3.2 Employee education and training should emphasize the need for handling hydrofluoric acid according to approved methods in order to avoid leaks and contact of vapour or liquid with eyes, skin, the gastro-intestinal tract or the respiratory system.

7.3.3 Before being placed on the job, new employees should be instructed thoroughly in the proper handling of hydrofluoric acid. Older employees should be reinstructed periodically. It is recommended that employees be questioned closely as often as necessary to insure their thorough understanding of essential facts.

7.3.4 Each employee should know the location and purpose of personal protective equipment and respiratory protective devices. He should understand the methods for their maintenance and be thoroughly trained in when and how to use them.

7.3.5 Each employee should know the location of safety showers, fountains for flushing eyes, hose lines, first-aid equipment and exits.

7.3.6 Only reliable, dependable and properly trained employees should be given the responsibility of operating valves which control the movement of hydrofluoric acid to and from storage tanks, tank cars and containers.

7.3.7 Employees should be trained to report to the proper authority all suspected leaks or equipment failures and any signs of illness. Burns or contact with liquid or vapours. Any unusual odour of hydrofluoric acid or evidence of spillage should be reported. They should be trained in the flushing of contaminated areas and in the proper and prompt application of neutralizing agents such as soda ash or lime. Employees thus trained should be provided with all the necessary protective devices to prevent personal injury.

7.3.8 Workers should be thoroughly informed as to the hazards arising from the improper handling of hydrofluoric acid. They should be cautioned

about spills, leaks and unusual vapour concentrations, and should be thoroughly instructed regarding the proper action to be taken in case these occur.

7.3.9 Each employee should know what to do in an emergency. He should be fully informed regarding first aid measures and should realize the necessity for prompt application of first aid in case of contact with hydrofluoric acid or exposure to the vapour.

7.3.10 Approved methods of handling the various types of hydrofluoric acid containers properly, including approved methods for transferring and emptying containers, and procedures for cleaning equipment, storage tanks and premises should be fully understood by supervisory and operational personnel.

7.4 Medical Examination

7.4.1 *Preplacement Examination* — Pre-employment examinations are advisable for all men handling hydrofluoric acid. The fitness of certain individuals to work in areas where the acid is handled should be evaluated carefully before they are assigned for general duties. Such individuals are those with:

a) Chronic respiratory diseases such as asthma, bronchiectasis, bronchitis and emphysema.

b) Seriously impaired vision in one or both eyes.

c) Any cardiac condition.

7.4.2 *Periodic Examination* — All employees who work constantly with hydrofluoric acid should have a thorough physical examination every six months, with special attention given to respiratory conditions.

7.5 Personal Protective Equipment

7.5.1 *Availability and Use* — Personal protective equipment is not an adequate substitute for good, safe working conditions, adequate ventilation, and intelligent conduct on the part of employees working with hydrofluoric acid. Such equipment may protect the individual wearing it while other in the area may be exposed to danger. The correct usage of personal protective equipment requires the education of the worker in the proper employment of the equipment available to him. Under conditions which are sufficiently hazardous to require protective equipment, its use should be carefully supervised. In all cases, the type of protective equipment selected should depend upon the existing degree of hazards. Employees should wear full coverage of clothing at all times. Working bareheaded, with shirt sleeves rolled up, or in an undershirt is exceedingly hazardous. Rubber shoes soled with neoprene or an equally resistant material or rubber made of same materials, a hat or protective head covering, a full face mask or chemical goggles with plastic lenses, and gauntlet-type gloves made of neoprene,

plasticized polyvinyl chloride or an equally resistant material should be used at all times in operating areas. Full protective equipment recommended when making repairs, connecting and disconnection tank cars, discharging containers, etc, consists of an acid hood with plastic window, an acid coat, rubber, neoprene or plasticized polyvinyl chloride overalls and gauntlet-type gloves made of neoprene, plasticized polyvinyl chloride or an equally resistant material. When leakage is abnormally large and the hydrofluoric acid vapour concentration is high or unknown, positive pressure hose masks, air line masks or self-contained breathing, apparatus should be used. The highest degree of protection is afforded by the use of an acid-proof air inflated suit with a mask and safety belt included. The manufacturer of the acid should be consulted regarding suppliers of this type of equipment.

7.5.2 *Chemical Safety Goggles* — Positive eye protective equipment such as rubber framed goggles equipped with plastic lenses should be worn whenever there is danger of hydrofluoric acid coming in contact with the eyes. Goggles should be carefully fitted by adjusting the nose piece and head band to insure maximum protection and comfort.

7.5.3 *Face Shields* — Plastic shields (full length 20 cm minimum) with forehead protection may be worn in addition to chemical safety goggles, where complete face protection is desirable. Chemical safety goggles should always be worn as an added protection where there is danger of material striking the eyes from underneath or from around the sides of the face shield.

7.5.4 *Respiratory Protection* — Air-line masks with the proper reducing valve and filter are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. Otherwise, self-contained breathing apparatus with stored oxygen or air, which allows greater mobility, should be used.

7.5.4.1 The latter type requires more highly trained men. In tank work, small manholes may make this apparatus unsuitable because of its bulk, although the style known as self-generating is specially designed for entrance and egress through small openings.

7.5.4.2 Air or oxygen supplied masks. These types of masks shall be equipped with full face pieces made of plastic, and shall be worn for protection in circumstances such as:

a) in emergencies when vapour concentration is not definitely known;

b) when the harmful vapour concentration is over 2 percent by volume or lacks a distinguishable odour;

c) when the oxygen content of the air may be less than 16 percent by volume;

d) in tank and equipment cleaning and repair work;

e) when the exposure period is to be over 30 minutes duration;

f) acid proof air inflated suits should be worn when acid vapour concentrations are suspected to be sufficiently high to cause skin irritation or injury.

7.5.4.3 Types of masks generally available include the following:

a) Air line masks supplied by plant compressed air are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. Such masks should be used only in conjunction with a suitable reducing or demand type valve and filter. The compressed air should be checked frequently to make certain that harmful gases from the decomposition of the lubricating oil used in the compressor or from impure air supply are not present.

b) Positive-pressure hose masks supplied by externally lubricated blowers are usually preferred to the air line type. Since these masks also depend on remote air supply, they should be used only where conditions will permit safe escape in the event of an air supply failure. Care shall be taken to locate the blower or air source in an area which is free from air contaminants.

c) Self-contained breathing apparatus which permits the wearer to carry a supply of oxygen or air compressed in a cylinder, or the self generating type which produces oxygen chemically, allows for greater mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air or oxygen supply carried. In tank work where small manholes are encountered, a self-contained breathing apparatus is usually unsuitable because of its bulk.

d) *Industrial canister type gas masks* — These types of masks shall be fitted with the proper canister for absorbing hydrofluoric acid vapour. They shall also be equipped with full face pieces made of plastic. The eye pieces should be made of clear plastic. They will afford protection against concentrations not exceeding 2 percent by volume when used in accordance with the manufacturer's instructions. The oxygen content of the air shall be not less than 16 percent by volume. The masks should be used for relatively brief exposure periods only, and the same canister should not be relied upon for more than 30 minutes. They may not be suitable for use in an emergency since at that time the actual vapour concentration is unknown and it may be very high. The wearer shall be warned to leave the contaminated area immediately on detecting the odour of harmful vapour. This is an indication that the mask is not functioning properly or that the vapour concentration is too high.

7.5.5 *Hats* — Safety or 'hard' hats will provide protection against accidental liquid leaks, falling tools or other objects. Brimmed felt hats

may be substituted for safety hats where the danger of falling objects is remote.

7.5.6 *Other Safety Supplies and Accessories*

7.5.6.1 *Ventilation* — Since the generally accepted threshold limit of hydrofluoric acid vapour is 3 parts per million by volume in air for an 8 hour working day, strong natural or forced drafted ventilation shall be provided in work areas.

7.5.6.2 *Safety showers* — Readily accessible, well marked and frequently inspected rapid action safety showers shall be available in the areas where hydrofluoric acid is handled. They should be capable of supplying large quantities of water under moderately high pressure. Blankets should be located near the safety showers.

7.5.6.3 *Eye baths* — Special eye washing fountains, bubbler drinking fountains or hoses with a gentle flow of tap water of drinking quality should be available for eye irrigation. As in the case of the safety showers, they should be readily accessible in the work area and should be inspected frequently.

7.5.6.4 *Rescue equipment* — Employees who are requested to enter tanks or enclosed storage spaces should be provided with an acid resistant rescue harness and a life line. These should be kept in proper condition adjacent to the equipment where it would be necessary to use them.

7.5.6.5 *Gloves* — Gloves of the type described in **7.4.1** should be tested before use by inflating them under water. Even an extremely small leak in a glove can admit sufficient acid to cause a severe burn. Before use, gloves should be dried thoroughly. After use, gloves should be neutralized, retested and dried thoroughly before reuse.

7.5.6.6 *Accessories*

a) Clean water in ample quantity should be immediately available whenever hydrofluoric acid is handled.

b) Hose connections should be available for flushing spilled acid.

c) Soda ash or lime should be available for neutralizing spilled acid.

d) Adequate facilities for washing protective clothing before removal shall be provided.

e) Acid contaminated tools should be washed and neutralized thoroughly before reuse.

f) Workmen should be provided with the necessary tools which should be kept in first class conditions, and they should be instructed to use them for repair of hydrofluoric acid equipment only. The borrowing of such tools by untrained and unprotected workmen may cause injuries. Frequent inspection of premises, equipment, tools and safety appliances is imperative.

8. FIRST-AID

8.0 General Principles — Speed in removing the patient from the contaminated atmosphere and in removing hydrofluoric acid from the skin or eyes is of prime importance. First aid shall be started immediately in all cases of contact with hydrofluoric acid in any form. All affected persons should be referred to a physician, even when immediate injury seems slight, and the physician should be given a detailed account of the accident.

8.1 Contact with Skin — Workers who have had contact with hydrofluoric acid should be subjected immediately to a drenching shower of water. The clothing should be removed as rapidly as possible, even while the victim is in the shower, and medical assistance obtained immediately. It is essential that the exposed area be washed with copious quantities of water for a sufficient period of time to remove all hydrofluoric acid from the skin. The exposed areas of skin should then be flushed with an aqueous solution containing 2 percent to 3 percent ammonia followed by liberal rinses of fresh water. Avoid getting the ammonia solution in the eyes. Following this, an ice-cold saturated solution of magnesium sulphate (Epson salt) or iced 70 percent alcohol should be applied for at least 30 minutes. If the burn is in such an area that it is impracticable to immerse the part, then the iced alcohol or the iced magnesium sulphate should be applied with saturated compresses, which should be changed at least every two minutes. The physician should be available by then to administer further treatment before the completion of the magnesium sulphate or alcohol treatment. If, however, a physician is not available by that time, it is then permissible to apply a generous quantity of paste made from powdered magnesium oxide and glycerine, freshly prepared. This is prepared by the addition of glycerine to magnesium oxide to form a thick paste. Oils and greases should not be applied except under instructions from a physician.

8.2 Contact with Eyes — The magnesia paste recommended in **8.1** for hydrofluoric acid burns should be used only for skin burns, not for eye burns. If liquid hydrofluoric acid has entered the eyes or if the eyes have been exposed to strong concentrations of acid vapour, they should be irrigated immediately and copiously with clean water for a minimum of 15 minutes. The eyelids should be held apart during the irrigation to insure contact of water with all the tissues of the surface of eyes and lids. A physician, preferably an eye specialist, should be called in attendance at the first possible moment. If a physician is not immediately available, instill one or two drops of 0.5 percent pontocain solution, or an equally effective aqueous tropical anaesthetic followed by a second irrigation for 15 minutes. No oils or oily ointments should be instilled unless ordered by a physician.

8.3 Ingestion — Ingestion of hydrofluoric acid causes severe burns of the mucous membrane of the mouth, throat, esophagus and stomach. Here copious irrigation is not feasible and no attempt should be made to pass a

stomach tube except by the attending physician. The patient should be encouraged to drink a large quantity of water without delay. After the hydrofluoric acid has been diluted with water, milk or milk of magnesia may be administered for their demulcent or soothing effect.

8.4 Inhalation — A worker who has been suspected of a possible severe exposure to gaseous hydrofluoric acid should be carried at once into an uncontaminated atmosphere. Even in the absence of symptoms, a worker shall not be permitted to return to work for at least 24 hours after a severe exposure because of the potential danger of developing severe edema of the lungs. A physician should be called immediately and, if a trained attendant is available, the administration of oxygen should be started at once.

8.4.1 In order to reduce the likelihood of the development of severe lung congestion (pulmonary edema), 100 percent oxygen should be administered as soon as possible after a severe exposure. Oxygen administration is most effective if expiration is made against a positive pressure of 4 cmH_2O. This may be accomplished readily by the use of a rubber tube connected to the outlet valve of a snugly fitting face mask and inserted to a depth of not more than 4 cm below the surface of water in a suitable container. The pressure resisting exhalation should be adjusted to the patient's surface. Oxygen inhalation shall be continued as long as necessary to maintain the normal colour of the skin and mucous membranes. In case of severe exposure, the patient should breathe 100 percent oxygen under positive exhalation pressure for 30-minutc periods every hour for at least 3 and preferably 6 hours. If there are no signs of lung congestion at the end of this period, and if breathing is easy and the colour is good, oxygen inhalation may be discontinued. Throughout this time the patient should be kept comfortably warm but not hot. Under no circumstances should a patient who has had a severe exposure be permitted to return home or back to work until examined and discharged by a physician who is aware of the nature of his exposure.

9. CLEANING AND REPAIRS OF TANKS

9.1 Preparation

9.1.1 The hazardous nature of tank inspection, cleaning or repairs requires that the foreman and crew be selected, trained and drilled carefully. These men should be fully familiar with the hazards and with the safeguards necessary for the safe execution of the work.

9.1.2 Written approval should be secured from the plant management before work is started on any major piece of equipment.

9.1.3 Pipelines into or out of the tank or other apparatus should be disconnected, preferably by removing a complete small section, and a blank flange should be secured on the open end of the line to protect against human error and unsuspected leaks. Valves and cocks in the pipeline should not be relied upon.

9.1.4 Danger signs should be placed prominently to indicate when workmen are in the tank or other apparatus.

9.1.5 The electrical switches shall be completely protected against the accidental starting of the agitating equipment or other moving parts located inside the tank or adjacent to the entrance.

9.2 Entering Tank

9.2.1 Before a tank is entered, tests shall be made by a qualified person to determine if further washing or purging is necessary; and during the course of the work further tests shall be made to insure that no oxygen deficiency exists, and that no harmful gas or vapour is present.

9.2.2 Before directing men to enter a tank, the foreman should make an inspection of the interior.

9.2.3 Anyone entering a tank shall be equipped with either a hose mask, an air line mask, a self-contained breathing apparatus with a full complement of personal protective clothing or an air suit together with a rescue harness and a life line. Anyone wearing a full complement of protective clothing and equipment should make sure that a tank can be left by the original entrance.

9.2.4 At least one other person shall be on guard at the entrance while repairs are being made to keep personnel in the tank under constant observation. At least two men shall be available to aid in rescue work if anyone in the tank is overcome.

9.2.5 Special ventilation and a continuous fresh air supply air recommended during the entire time men are cleaning, inspecting, or repairing the tank.

9.2.6 A hose mask, an air-line mask, or a self-contained breathing apparatus or an air suit, together with rescue harness and life line, should be located outside the tank entrance. This equipment should be used for rescue if necessary, regardless of the type of respiratory protection or the air supply which is provided for employees inside the tank.

9.2.7 In addition to protecting the workmen actually engaged in cleaning and repairing the tank, attention should be paid to the protection of workers in nearby areas.

9.2.8 The portable electric lights and power tools should be of the three-wire, grounded, explosion-proof type approved for use in hazardous locations. They should be maintained in excellent condition.

9.3 Additional Precautions — Cleaning or making repairs inside a tank may be hazardous even though the tank contained a non-toxic, non-flammable material. In addition to the precautions given above and to those

generally recommended for tank work, further precautions are recommended as follows

9.3.1 The tank or equipment shall first be emptied completely of all liquid.

9.3.2 The remaining gas in the tank should then be vented to the absorption system, the tank opened, and all pipes leading to and from the tank drained, disconnected, and blanked. The tank should be filled rapidly with water (it is essential that a large volume of water be fed to the tank to dilute the remaining acid rapidly).

9.3.3 The tank should be emptied, filled with water, and then emptied again. After this, it should be thoroughly purged with fresh air, and then tested for breathing purposes The tank should then be in condition to enter. On occasions, it may be necessary to use soda ash for neutralizing residual acid.

9.3.4 After repairs have been completed, the tank should be cleaned thoroughly and dried before reassembling and refilling.

10. WASTE DISPOSAL

10.0 Waste disposal of hydrofluoric acid and material containing it depends to a great extent upon local conditions. All Central, state and local regulations regarding health and pollution shall be followed. The supplier of acid may be consulted for instructions and advice.

10.1 Disposal of Small Quantities

10.1.1 Anhydrous or aqueous hydrofluoric acid in limited quantities may be dumped into a trench dug in the ground in an isolated location not generally accessible to employees or the public. The trench should have a volume at least ten times that of the acid on hand for disposal. After the waste acid is dumped, commercial lime or soda ash sufficient to neutralize the acid should be added to the trench Then the trench should be filled in with earth and covered with lumber or sheet metal until the earth settles.

10.1.2 Small quantities of acid, in emergencies, may be flushed down drains using large volumes of water to rinse and dilute it. Drains and sewers should then be neutralized with lime slurry or soda ash solution to prevent deterioration of tile or metals by the acid

10.1.3 Disposal operations should be conducted in outside locations where the vapours can be dissipated in the air. If disposal inside buildings is necessary, adequate natural or forced draft ventilation should be provided.

10.2 Disposal of Large Quantities

10.2.1 Waste anhydrous hydrofluoric acid as a gas vented from storage tanks or processes should be conducted to an absorption system to prevent pollution of the atmosphere.

10.2.2 The absorption of gas may be accomplished by conducting it into a packed tower of proper size over which is circulated water or an alkaline solution in sufficient volume to effect complete absorption. The disposal of waste weak hydrofluoric acid or the fluorides thus formed will depend on the economics of the particular case, and to a great extent upon local conditions and regulations.

10.2.3 Wastes containing dilute hydrofluoric acid or fluorides in solution may be exceedingly corrosive to ceramic materials and to ferrous metals. This fact should be considered carefully before directing such wastes into drains or sewers. In general, dilution, neutralization or precipitation with lime suffices to avoid nuisances or harmful effects of fluoride-containing wastes, however, local, state and Central requirements should be carefully considered in each case for the fluoride content may be only part of the disposal problem.

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